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# SPACE SIMULATORS FOR LASER OPTICS

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I am going to describe different approaches that are being utilized in the testing of laser optical systems. One of the most crucial areas in the testing phase is the stability of the laser optics that is mounted inside the space simulator.

In each case the individual user has his own ideas as to how to approach setting up the space simulating facility and how it should be utilized.

In all of the cases we are going to discuss, you will notice that the customers all utilize different high vacuum pumping systems and different temperature simulation thermal systems, as well as different ways that they mount the laser optical system to provide what they feel is the best possible stability.

## FIRST SLIDE

This shows a comparatively large space simulation facility that is 6' in diameter x 6' deep. The reason for the large size of this facility is the fact that this particular customer is mounting a Newport table inside the space simulator with the legs going through the bottom of the chamber via special vibration isolation connections.

The vacuum system for this chamber utilizes a turbomolecular pump with a valved system, as well as roughing pump of the mechanical type with a molecular sieve absorber and a main foreline valve. This enables the customer to obtain high vacuums in the $10^{-7}$ torr range, and as a safety when they do their actual testing, they shut the pump off and close the valve to the roughing pump and the turbomolecular pump. This eliminates any possible vibration transmition to the chamber. All vacuum piping contains vibration isolation bellows as a safety.

The chamber is furnished with a multitude of windows all around the chamber for easy viewing by the customer, and all of the windows are provided with special covers. An inside shroud is designed for operation with a flooded nitrogen system, providing only the extreme low temperature that can be obtained utilizing liquid nitrogen.

From the customer's liquid nitrogen storage tank a nitrogen pump provides the liquid to the shroud connection, which has liquid nitrogen control valves tied into a liquid nitrogen temperature controller. It is a once-through system discharging, through insulated piping, out of building.

This is an extremely costly system, not only because of the large chamber required to hold the Newport table, but also because of the high cost of the special

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bellows assembly need for the penetration of the Newport table leg assembly. The large chamber requires a bigger pumping system and a large cryogenic shroud assembly, adding to the cost. The advantage is the laser system is mounted directly to the Newport table, providing for direct vibration isolation.

SECOND SLIDE

This shows a smaller thermal vacuum system, again with windows and covers, but with a mounting fixture such that the chamber and its mounting fixture sit directly on a Newport table. Thus the isolation is provided not only for the test item, but for the chamber itself. The chamber in this case only has to be sized for the laser test item.

The chamber vacuum system in this case is a cryopumping system with a main valve and a mechanical roughing pump with its valve. Again, as in the previous condition, when the customer is ready to do his testing, the pumps are shut down and the valves are closed. For the 10 to 15 minute testing required, this short time period without the vacuum system operating has almost no effect on the vacuum level.

A shroud is provided inside the chamber that is both cooled and heated with a mechanical refrigeration system. This refrigeration system is of the cascade type, cooling a secondary brine which also has a heater in the circuit for the heating of the brine. A special brine circulating pump is provided in a closed loop condition for circulation of the conditioned brine through the shroud. This provides the chamber with a thermal conditioning system giving a temperature range of from -73°C to +125°C. The refrigeration system is also provided with valves in the line, so that it too may be shut down during actual testing to help eliminate any external vibration.

The chamber and the Newport table with the control panel are all mounted inside a clean room facility, whereas all of the machinery, the roughing pump, and the cryopump compressor are mounted on an external framework outside the clean room facility.

With a brine thermal system, temperature control of ±.5°C is able to be maintained. A temperature microprocessor programmer, with built-in control functions and logic for operation of the refrigeration/brine thermal system, enables accurate stabilization control on the shroud, as well as very accurate ramp rates and cycling all automatically controlled. To further automate the operation, the vacuum system contains a Granville Phillips microprocessor ionization gauge with a digital Convectron gauge, allowing for automatic programming of the vacuum system from roughing to high vacuum, automatic opening and closing of vacuum valves, as well as shut-down of the roughing system when the cryopump is in full operation.

THIRD SLIDE

This shows a small thermal space simulator, again with windows and cover plates, except that this chamber sits directly on the Newport table. It utilizes a cryopump with a main valve, as well as a mechanical forepump with a valve. The

refrigeration system is all mechanical and is actually the same refrigeration system package that was utilized for the chamber shown in Slide 2.

This customer utilizes one or the other of his two chambers, but never both chambers at the same time. This is being done because of two different laser systems that are being tested independently, each of a different configuration, and the space chamber system is required to be shipped with the laser system.

The chamber again is mounted inside the clean room, with all machinery external of the clean room area, and during actual testing, the vacuum system and the thermal system are shut down, and the main valves are closed off to the chamber.

This thermal space simulator also incorporates a thermal microprocessor programmer, as well as a vacuum microprocessor, for complete automation of both thermal ramping and cycling and vacuum automation of operation.

## FOURTH SLIDE

This shows a space simulator, again with windows and cover plates, that is mounted on an isolated foundation, not a table. This unit also utilizes a cryopump with a main valve, a mechanical roughing system with a valve, both of which are shut down and provided with quick disconnects that are utilized during the actual testing.

The thermal system is a conditioned recirculated gaseous nitrogen system. It consists of a high pressure blower, electric heaters, and liquid nitrogen injection valves. A hermetic enclosure encapsulates not only the blower and heaters, but also the blower motor, eliminating all seals with their inherent problems. The enclosure and piping are pressurized with gaseous nitrogen and recirculated via the blower. The gaseous nitrogen is cooled via the injection of liquid nitrogen and heated via the electric heaters in the enclosure. This provides a thermal system with a temperature range of -300°F to +300°F (-185°C to +150°C). Since we are recirculating a gas, not a liquid, we must provide large diameter interconnecting piping and shroud tubes, to minimize pressure drop. Control is provided via the injection of liquid nitrogen and the energizing of the electric heaters. Shut-off valves and quick disconnects are provided.

All of the machinery is mounted remote of the chamber in a completely separate area, and this customer not only shuts off the valves to the chamber, but utilizes the quick disconnects to remove the lines to the chamber, so that no vibration can be transmitted from the external equipment to the chamber while tests are being accomplished.

A remote control console contains all instrumentation for the space chamber facility. Microprocessor digital-type instrumentation for both the thermal system and for the vacuum system are provided, as well as recording capabilities for both temperature and vacuum. An umbilical cord connects the instrumentation to the chamber proper.

## CONCLUDING REMARKS

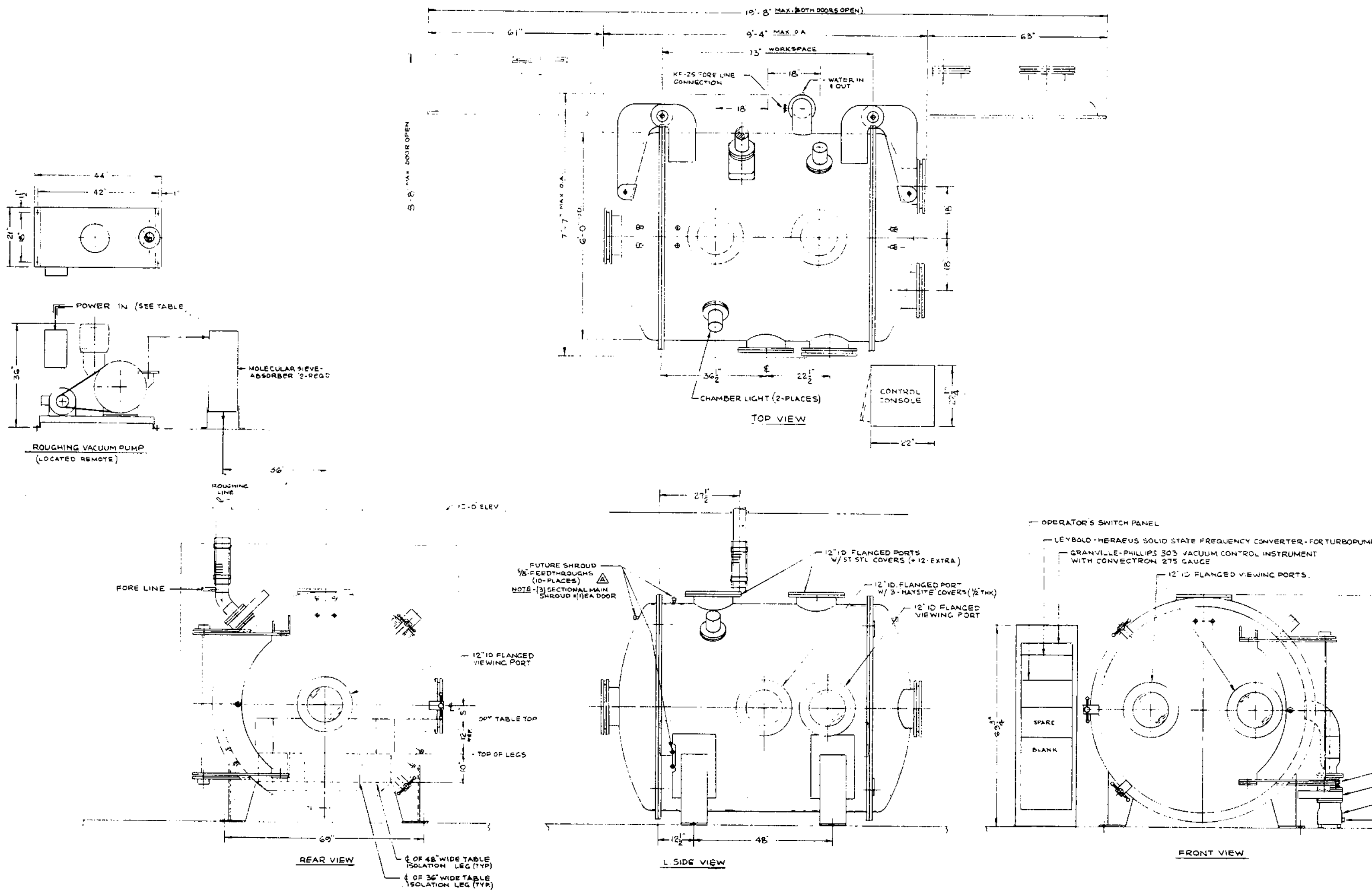
Regardless of the size or configuration of the space chamber, the basic shell of the chamber is manufactured of type 304 stainless steel that is heliarc welded, with the inside of the shell polished to a number 4 finish. All of the shrouds are manufactured of deoxidized copper sheet that has tubes welded to the exterior, and designed with the proper circuiting and headering for the heat transfer medium that is to be circulated. The outside of the shroud is then polished, with the inside treated and provided with a black finish having an emissivity of .9 or better. Copper is utilized for the shroud because of its high thermal conductivity and its ease of manufacture.

All completed units are thoroughly pre-tested for vacuum and thermal conditions with the space chamber empty of a test item and without the isolation system.

In all of the above cases the chamber is under a deep vacuum of a minimum of $10^{-6}$ torr or better, and all of the testing is accomplished within a 10 - 15 minute period. In all of the cases the 15-minute period is short enough so that there is no appreciable deterioration of either vacuum or thermal conditions while tests are being accomplished and with all of the machinery shut down or disconnected from the chambers.

Each customer feels very strongly that he has completely isolated any vibration being transmitted to his test item.

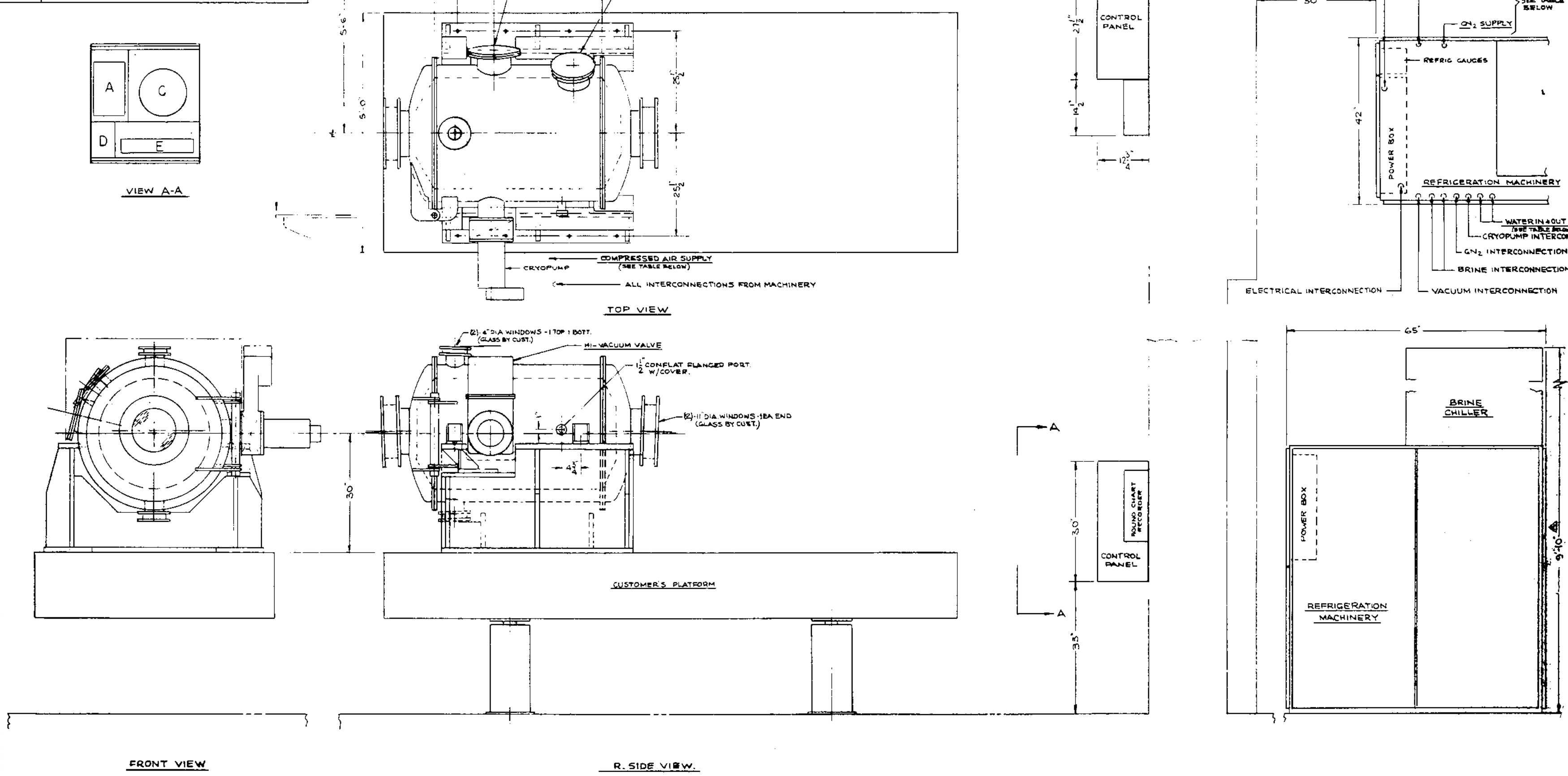
All of the above units are currently in operation successfully from the customer's point of view, and the ultimate determination of which type of approach for the design of the facility must be made by the customer, not by the manufacturer.



19'-8" MAX. (BOTH DOORS OPEN)
61"
9'-4" MAX O.A.
63"
73" WORKSPACE
KF-25 FORE LINE CONNECTION
WATER IN & OUT
7'-7" MAX O.A.
6'-0" I.D.
CHAMBER LIGHT (2-PLACES)
CONTROL CONSOLE
TOP VIEW
POWER IN (SEE TABLE)
MOLECULAR SIEVE-ABSORBER (2-REQD)
ROUGHING VACUUM PUMP
(LOCATED REMOTE)
ROUGHING LINE
FORE LINE
12" ID FLANGED VIEWING PORT
OPT TABLE TOP
TOP OF LEGS
REAR VIEW
℄ OF 48" WIDE TABLE ISOLATION LEG (TYP)
℄ OF 36" WIDE TABLE ISOLATION LEG (TYP)
FUTURE SHROUD
5/8 FEEDTHROUGHS (10-PLACES)
NOTE-(3) SECTIONAL MAIN SHROUD & (1) EA DOOR
12" ID FLANGED PORTS W/ ST STL COVERS (+12 EXTRA)
12" ID FLANGED PORT W/ 3-HAYSITE COVERS (1/2" THK)
12" ID FLANGED VIEWING PORT
L SIDE VIEW
OPERATOR'S SWITCH PANEL
LEYBOLD-HERAEUS SOLID STATE FREQUENCY CONVERTER-FOR TURBOPUMP
GRANVILLE-PHILLIPS 303 VACUUM CONTROL INSTRUMENT WITH CONVECTRON 275 GAUGE
12" ID FLANGED VIEWING PORTS
SPARE
BLANK
BELLOWS
HI-VACUUM VALVE
HI-VACUUM PUMP (TURBOPUMP)
WATER IN & OUT (SEE TABLE)
FRONT VIEW

— INSTRUMENTATION —

| SYMBOL | DESCRIPTION |
|---|---|
| A | MICROTENN PROGRAM CONTROL & LOGIC SYSTEM |
| B | |
| C | ROUND CHART TEMP. & PRESSURE RECORDER - 2 PEN |
| D | CONNECTRON GAUGE |
| E | IONIZATION GAUGE |

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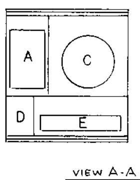
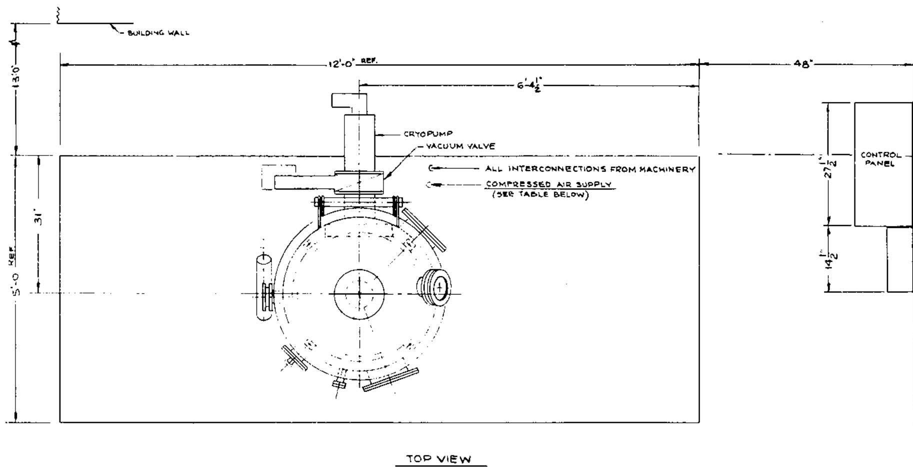
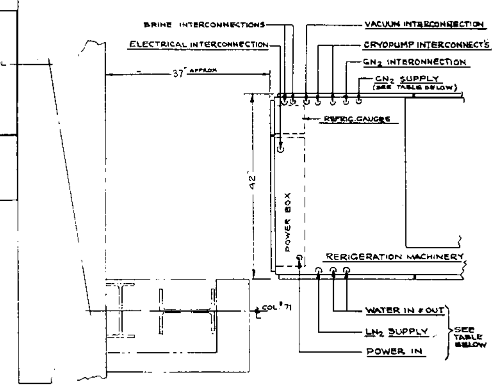
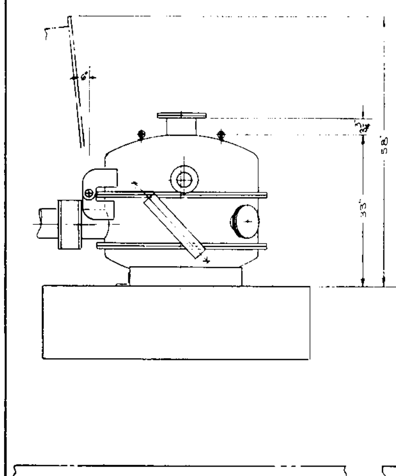



VIEW A-A

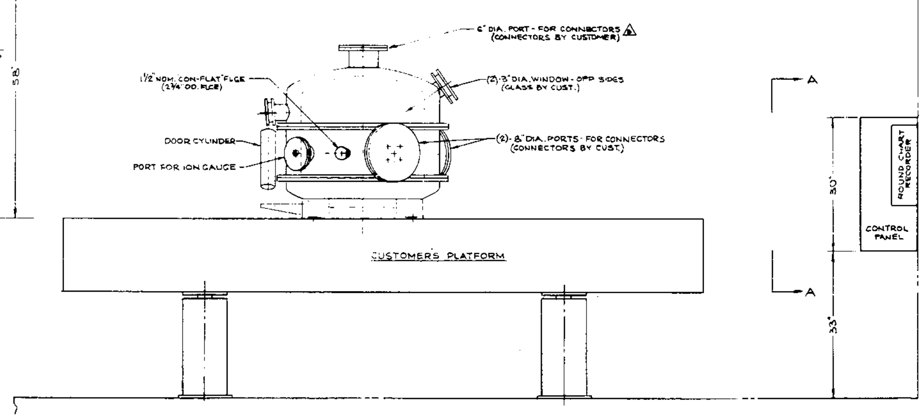



TOP VIEW

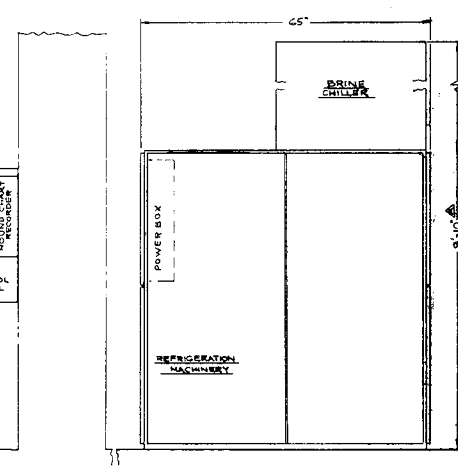



FRONT VIEW




R. SIDE VIEW

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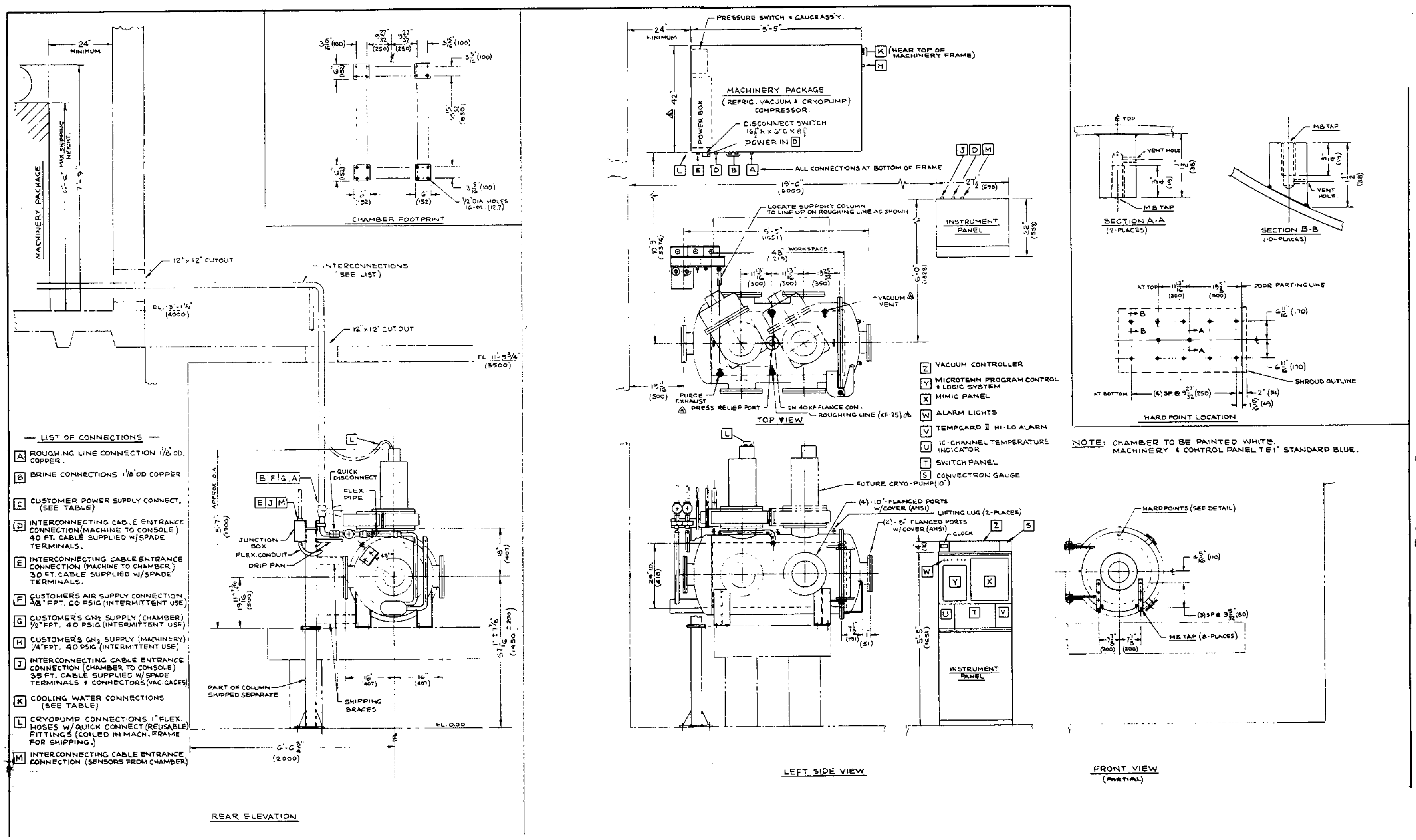
LIST OF CONNECTIONS
A ROUGHING LINE CONNECTION 1/8" OD. COPPER.
B BRINE CONNECTIONS 1/8" OD COPPER
C CUSTOMER POWER SUPPLY CONNECT. (SEE TABLE)
D INTERCONNECTING CABLE ENTRANCE CONNECTION (MACHINE TO CONSOLE) 40 FT. CABLE SUPPLIED W/SPADE TERMINALS.
E INTERCONNECTING CABLE ENTRANCE CONNECTION (MACHINE TO CHAMBER) 30 FT. CABLE SUPPLIED W/SPADE TERMINALS.
F CUSTOMERS AIR SUPPLY CONNECTION 3/8" FPT. 60 PSIG (INTERMITTENT USE)
G CUSTOMER'S GN2 SUPPLY (CHAMBER) 1/2" FPT. 40 PSIG (INTERMITTENT USE)
H CUSTOMER'S GN2 SUPPLY (MACHINERY) 1/4" FPT. 40 PSIG (INTERMITTENT USE)
J INTERCONNECTING CABLE ENTRANCE CONNECTION (CHAMBER TO CONSOLE) 35 FT. CABLE SUPPLIED W/SPADE TERMINALS & CONNECTORS (VAC. CAGES)
K COOLING WATER CONNECTIONS (SEE TABLE)
L CRYOPUMP CONNECTIONS 1" FLEX. HOSES W/QUICK CONNECT (REUSABLE) FITTINGS (COILED IN MACH. FRAME FOR SHIPPING.)
M INTERCONNECTING CABLE ENTRANCE CONNECTION (SENSORS FROM CHAMBER)
REAR ELEVATION
CHAMBER FOOTPRINT
1/2" DIA HOLES 16-OL (12.7)
MACHINERY PACKAGE
12" x 12" CUTOUT
INTERCONNECTIONS (SEE LIST)
EL. 13'-1 1/2" (4000)
EL. 11'-5 3/4" (3500)
EL. 0.00
QUICK DISCONNECT
FLEX PIPE
JUNCTION BOX
FLEX. CONDUIT
DRIP PAN
PART OF COLUMN SHIPPED SEPARATE
SHIPPING BRACES
PRESSURE SWITCH & GAUGE ASS'Y.
MACHINERY PACKAGE (REFRIG., VACUUM & CRYOPUMP) COMPRESSOR
DISCONNECT SWITCH
POWER BOX
POWER IN D
K (NEAR TOP OF MACHINERY FRAME)
ALL CONNECTIONS AT BOTTOM OF FRAME
LOCATE SUPPORT COLUMN TO LINE UP ON ROUGHING LINE AS SHOWN
WORKSPACE
INSTRUMENT PANEL
VACUUM VENT
PURGE EXHAUST
PRESS RELIEF PORT
DN 40 KF FLANGE CON.
ROUGHING LINE (KF-25)
TOP VIEW
Z VACUUM CONTROLLER
Y MICROTENN PROGRAM CONTROL & LOGIC SYSTEM
X MIMIC PANEL
W ALARM LIGHTS
V TEMPGARD II HI-LO ALARM
U 16-CHANNEL TEMPERATURE INDICATOR
T SWITCH PANEL
S CONVECTRON GAUGE
FUTURE CRYO-PUMP (10")
(4)-10"-FLANGED PORTS W/COVER (ANSI)
LIFTING LUG (2-PLACES)
(2)-8"-FLANGED PORTS W/COVER (ANSI)
CLOCK
LEFT SIDE VIEW
SECTION A-A (2-PLACES)
SECTION B-B (10-PLACES)
M8 TAP
VENT HOLE
DOOR PARTING LINE
SHROUD OUTLINE
AT TOP
AT BOTTOM
(4) SP. @ 9 27/32 (250)
HARD POINT LOCATION
NOTE: CHAMBER TO BE PAINTED WHITE. MACHINERY & CONTROL PANEL "TEI" STANDARD BLUE.
HARDPOINTS (SEE DETAIL)
M8 TAP (8-PLACES)
FRONT VIEW (PARTIAL)